PERCHLORATE IN DRINKING WATER

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INTRODUCTION

Concentrations of perchlorate (ClO_4^-) have been detected in water at many locations in the United States. This presentation addresses the occurrence of perchlorate in U.S. drinking water supplies and its natural occurrence in northern Chile, and briefly discusses results of an epidemiological study conducted in three coastal cities in the Atacama Desert of Chile..

PERCHLORATE

Perchlorate is a highly oxidized form of chlorine. Perchlorate is often associated with cations such as ammonium, sodium, and potassium. These perchlorate salts are quite soluble in water, and the resulting highly soluble anion is very mobile in the environment. Although it is highly oxidized, the anion tends to react slowly with common reducing agents, and consequently is persistent in the environment (USEPA, 2000).

Occurrence of Perchlorate in U.S. Drinking Water

The geographical distribution of perchlorate occurrence in the U.S. is widespread. In March 1997, improved analytical methods greatly enhanced the capability of laboratories to detect perchlorate at low concentrations. Subsequently, perchlorate has been detected in municipal drinking water supplies in California, Nevada, Utah, and Arizona, including Lake Mead and the downstream Colorado River. Additionally, preliminary surveys conducted by the American Water Works Service Company of groundwater from wells show a broad geographical distribution of perchlorate occurrence (USEPA, 2000). Of the 16 states included in the surveys, groundwater testing positive for perchlorate was found in California, Iowa, Indiana, and Pennsylvania. Nevada and Utah were not included in these surveys. Initial estimates made by the U.S. Environmental Protection Agency suggest that perchlorate has been manufactured, used, or shipped to facilities in at least 43 states. As more surveys are conducted, it is likely that the reported areal extent of perchlorate occurrence will continue to expand.

Most detections of perchlorate in the U.S. have been attributed to its industrial use as an oxidizer in solid rocket boosters. It is also used in the manufacture of some munitions, missiles, matches, and fireworks. Perchlorate has a short shelf life; inventories must be renewed periodically, resulting in disposal of outdated supplies. Occurrences of perchlorate may also be attributable to its presence in fertilizer imported from Chile.

Natural Occurrence of Perchlorate in Chile

Naturally-occurring perchlorate is ubiquitously associated with nitrate-bearing caliche in the Atacama Desert region of northern Chile (Ericksen, 1981). The Atacama is one of the most arid places in the world, with measurable rainfall occurring as infrequently as once every five years. The arid environment of the Atacama has persisted from the Miocene, allowing slow accumulation and preservation of saline deposits in areas of low relief. This region is characterized by a lack of nitrogen-

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using plants and a paucity of soil organisms. The richest nitrate-perchlorate deposits are located in areas of low relief within two distinct geologic environments: 1) 1to 3 meter thick layers in alluvium at a depth of 1 to 2 meters, and 2) 10 to 50 centimeter thick fracture-filling veins in bedrock at a depth of 3 to 6 meters. These firmly cemented, saline-rich deposits are believed to be composed of condensates from Pacific Ocean sea spray and fallout from Andean volcanic eruptions. Saline constituents in the nitrate deposits have been repeatedly leached, mobilized and reprecipitated, enriching their concentrations of nitrate, gypsum, anhydrite and perchlorate. The perchlorate within these deposits is believed to be the result of photochemical reactions that oxidize gaseous chlorine to perchlorate in the lower atmosphere and at the soil surface. For more than a century, these deposits have been mined and shipped worldwide for use in gunpowder, munitions, and fertilizers. Until recent decades, nitrate export was a thriving industry in a number of cities along the Chilean coast.

Perchlorate and Human Health

Perchlorate in drinking water is of concern due to physiological effects of the anion. At large doses, perchlorate has been shown to reversibly inhibit the uptake of iodine by the thyroid gland. Normal thyroid function is necessary for growth and neurological development. Studies to identify and monitor potential human health effects began soon after detection of perchlorate in drinking water. Two epidemiological studies have recently been completed utilizing neonatal screening data from state health departments in California and Nevada. These studies did not find an increased incidence of congenital hypothyroidism in the newborns, or a decrease in neonatal thyroxine levels, associated with environmental perchlorate concentrations as large as 15 µg/L. Two occupational health studies conducted in the U.S. found no indication of thyroid suppression or other adverse health effects in healthy adults from chronic occupational exposure to airborne perchlorate. There have been few opportunities to study possible effects of long-term exposure to environmental perchlorate or to observe its effects on young children.

In Chile, an epidemiological study was recently conducted in the coastal Atacama cities of Taltal, Chañaral, and Antofagasta (Crump, et. al., 2000). Naturally-occurring concentrations of perchlorate as large as 120 µg/L appear to have remained constant in drinking water supplies for several decades. The investigation included newborns and school-age children who were lifelong residents of the study cities. Mandatory neonatal screening records of thyroid hormone levels were compared across the three study cities, and school-age children were physically examined and blood and urine samples analyzed for indicators of thyroid function. Although perchlorate concentrations ranged widely among the study cities, results indicate that daily exposure to perchlorate in drinking water at concentrations as large as 120 µg/L did not adversely affect the children's thyroid health. This region of Chile offers opportunities to further expand knowledge of the relationships between perchlorate and human health.

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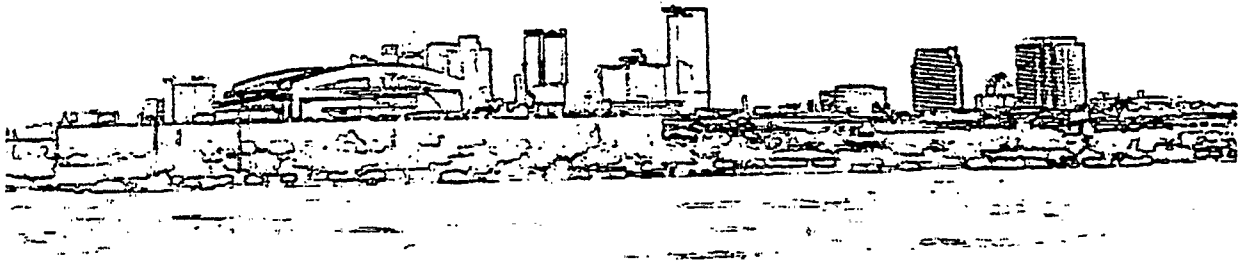

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